GOES-R Analysis Facility for Instrument Impacts on Requirements (GRAFIIR)

An Efficient End-to-End Semi Automated GOES-R ABI Algorithm Performance Analysis and Implementation Verification System

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OBJECTIVE

➢**GRAFIIR is a facility established to leverage existing capabilities and those under development for both current GOES and its successor ABI in data processing and product evaluation to support GOES-R analysis of instruments impacts on meeting user and product requirements.**

➢**GRAFIIR is for "connecting the dots", the components that have been built and/or are under development, to provide a flexible frame work to effectively adopt component algorithms toward analyzing the sensor measurements with different elements of sensor characteristic (i.e. noise, navigation, band to band co-registration, etc.) and its impact on products.**

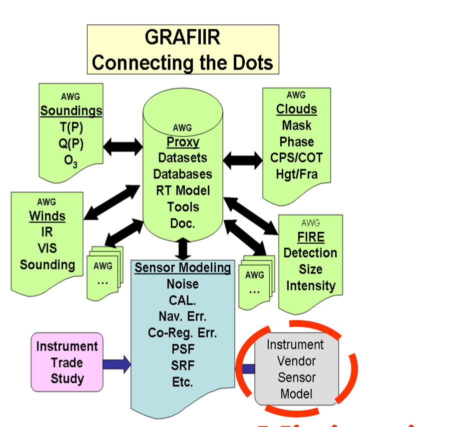
➢**GRAFIIR is to assess and evaluate many of the GOES-R data and products (i.e. imagery, clouds, derived products, soundings, winds, etc.) in a consistent way to ensure the instrument effects on the products can be fully accounted for, characterized and product performance can be analyzed.**

➢**GRAFIIR is a coordinated team effort from GOES-R Risk Reduction and Algorithm Working Group and other related projects. It will not independently develop any new algorithms or processing, but will leverage work already available or under development.**

➢**GRAFIIR is a key part of the government's waiver analysis plan concerning the ABI**

ABI Spectral Characteristics

Future GOES imager (ABI) band	Wavelength range (µm)	Central wavelength (µm)	Nominal subsatellite IGFOV (km)	Sample use
1	0.45–0.49	0.47	1	Daytime aerosol over land, coastal water mapping
2	0.59–0.69	0.64	0.5	Daytime clouds fog, insolation, winds
3	0.846–0.885	0.865	1	Daytime vegetation/burn scar and aerosol over water, winds
4	1.371–1.386	1.378	2	Daytime cirrus cloud
5	1.58–1.64	1.61	1	Daytime cloud-top phase and particle size, snow
6	2.225–2.275	2.25	2	Daytime land/cloud properties, particle size, vegetation, snow
7	3.80–4.00	3.90	2	Surface and cloud, fog at night, fire, winds
8	5.77–6.6	6.19	2	High-level atmospheric water vapor, winds, rainfall
9	6.75–7.15	6.95	2	Midlevel atmospheric water vapor, winds, rainfall
10	7.24–7.44	7.34	2	Lower-level water vapor, winds, and SO_2
11	8.3–8.7	8.5	2	Total water for stability, cloud phase, dust, SO_2 rainfall
12	9.42–9.8	9.61	2	Total ozone, turbulence, and winds
13	10.1–10.6	10.35	2	Surface and cloud
14	10.8–11.6	11.2	2	Imagery, SST, clouds, rainfall
15	11.8–12.8	12.3	2	Total water, ash, and SST
16	13.0–13.6	13.3	2	Air temperature, cloud heights and amounts



Missing piece

GRAFIIR primarily uses AWG Proxy Team simulated ABI data:
- ABI data generated from WRF model analysis performed on a super computer.
- Full disk (15-min, 6-km)
- CONUS (5-min, 2-km)
- Mesoscale (1-min, 667-m)
- All 16 bands

Modeling of ABI Instrument Effects
(Using Specifications from the ABI PORD, April 2003)

Four instrument effects have been applied to simulated (from WRF) ABI data which have been remapped to an ABI-like grid and quantized for ABI bit depth:

➢ **Noise (NEdT or NEdR)**
- **Vis/NIR (bands 1-6): SNR is 300:1 at 100% albedo**
- **IR (bands 7-15): NEdT at 300K is 0.1K, (band 16): 0.3K**

Random noise is generated such that for m lines by n elements in an image a random number generator is used on all mXn points where the standard deviation of what will be added to those mXn points is the noise (such as the NEdR equivalent of 0.1K at 300K for IR bands or 300:1 in reflectance units).

➢ **Calibration Offset**
- **IR Bands: ABI Spec is for absolute accuracy of 1K**
- **Vis/NIR Bands: ABI Spec is for absolute accuracy of 3%**

➢ **Navigation Error**

Spec Navigation Error is 21 microradians. This spec is the largest of any of the navigation/co-registration type errors. To simulate this error a random compass direction (0-359.99 degrees) is selected for each pixel and a normalized random distribution for distance based on 21 micro radians (0.75km) is added. Then the radiance for that pixel is "smudged" in that direction using linear interpolation. The result is a new image with the original Lat/Lon grid but slightly altered radiances. A few pixels may have large differences from the original because they were on the edge of a feature such as a cloud.

➢ **Striping**

The striping specification is "not to exceed the noise". Assuming the ABI will have a detector array that will result in 100 lines of remapped data, striping is added to one of the first 100 lines and every 100th line after that.

➢ **Combination of the above ABI instrument effect: (1X & 3X)**

Datasets were created that applied all four instrument effects at 1X spec and 3X spec to determine their effects on certain algorithms.

Glance: A Semi-Automatic Efficient Evaluation Tool

baseline_cld_hght_seviri_cloud_top_temperature Variable Comparison

report produced with glance, version 0.2.6.10
comparison generated Mon Oct 19 17:54:38 2009 by user wstraka on craackly.ssec.wisc.edu

file A:

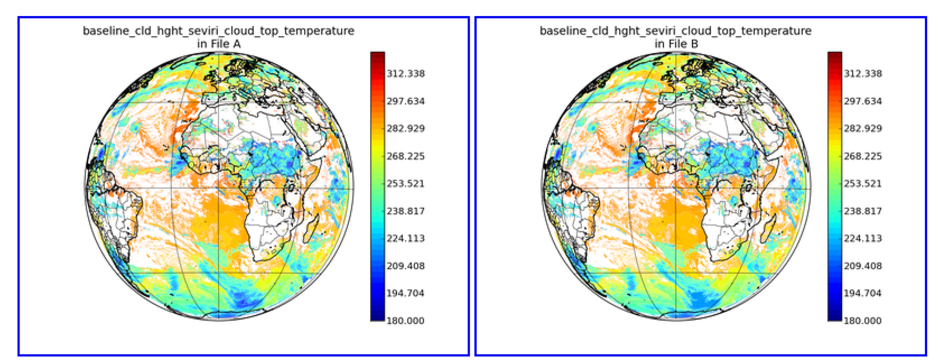
path: /home/wstraka/geocat/data_in_out/geocatL2.Meteosat-8.2006237.120000.ALLATONCE.ALLALG.hdf
md5sum for file A: 56cb4b93e00b7894d38788ca9439737f
last modified: Thu Oct 15 00:47:36 2009

file B:

path: /home/wstraka/geocat/data_in_out/geocatL2.Meteosat-8.2006237.120000.hdf
md5sum for file B: 36d63d0044e721c4608d8263739c0494
last modified: Mon Oct 19 17:45:05 2009

latitude: pixel_latitude
longitude: pixel_longitude

Original Data



Comparison Information

variable name: baseline_cld_hght_seviri_cloud_top_temperature
epsilon value: 0.1
"missing" data value in A: -32768
"missing" data value in B: -32768

Statistical Summary

Finite Data Statistics
- a_finite_count*: 5839352
- a_finite_fraction*: 0.4238
- b_finite_count*: 5830257
- b_finite_fraction*: 0.4231
- common_finite_count*: 5829663
- common_finite_fraction*: 0.4231
- finite_in_only_one_count*: 10283
- finite_in_only_one_fraction*: 0.0007463

General Statistics
- a_missing_value*: -32768
- b_missing_value*: -32768
- epsilon*: 0.1
- max_a*: 324.1
- max_b*: 324.1
- min_a*: 180
- min_b*: 180
- num_data_points*: 13778944
- shape*: (3712, 3712)
- spatially_invalid_pts_ignored_in_a*: 3498035
- spatially_invalid_pts_ignored_in_b*: 3498035
- trouble_points_count*: 87676
- trouble_points_fraction*: 0.006363

Numerical Comparison Statistics
- correlation*: 0.9979
- diff_outside_epsilon_count*: 77393
- diff_outside_epsilon_fraction*: 0.01328
- max_diff*: 106.1
- mean_diff*: 0.08044
- median_diff*: 0
- perfect_match_count*: 5666354
- perfect_match_fraction*: 0.972
- rms_diff*: 1.748
- std_diff*: 1.745

➢ GLANCE is a Python software tool in development by the UW-CIMSS GRAFIIR team to efficiently & consistently compare two datasets in a semi-automated way. "Glance at the differences."

➢ The code is user input driven, so statistics, such as epsilon (threshold) are dynamically changed by user input for each variable.

➢ Glance can generate a report in html format which includes product images, difference images, scatter plots, and histograms; also included are various statistics.

➢ Compare algorithm output to ensure processing system, algorithm and ancillary datasets are installed correctly.

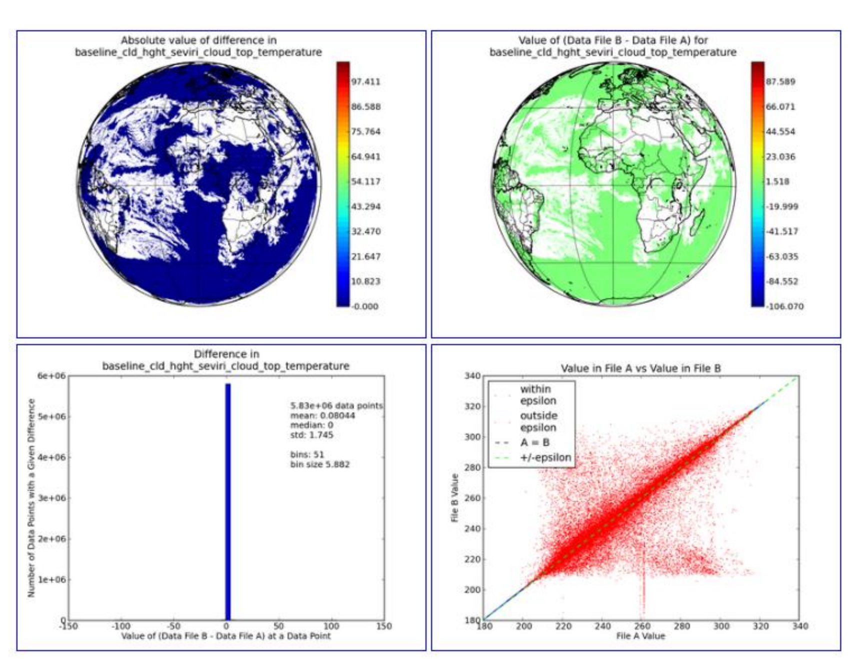
➢ Compare algorithm outputs and obtain useful statistics for varying instrument effect(s)/added noise

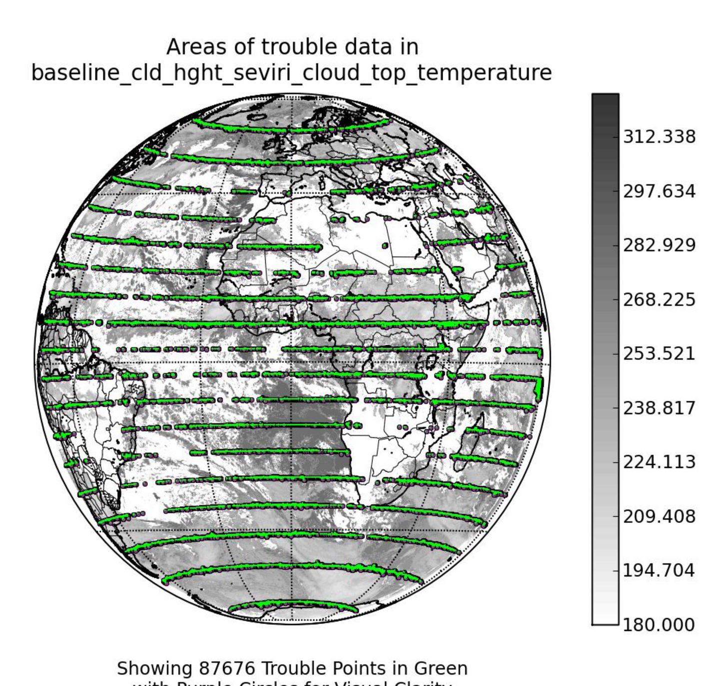
➢ Automating time consuming manual GRAFIIR analyses

This Glance report demonstrates Cloud Top Height run on SEVIRI data (12:00 UTC 25 Aug 2006).
- File A is the entire full disk processed at one time.
- File B is the full disk divided into "chunks" and processed one chunk at a time.

What happens when certain algorithms, such as cloud top temperature which rely on n by n uniformity values, are processed in multiple chunks and then processed later as a single chunk (full disk at a time) for comparison?

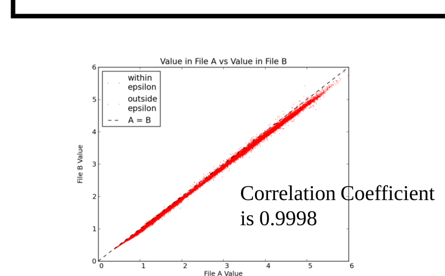
Trouble spots manifest themselves in "stripes" along the beginning and ending lines of each chunk as well as a spread in the data greater than machine precision, as exhibited by the scatter plot.

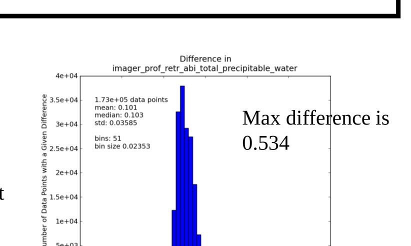




Soundings Example

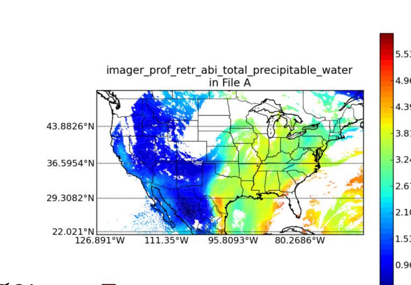
"Pure" Proxy Team CONUS image vs "1x" instruments effects



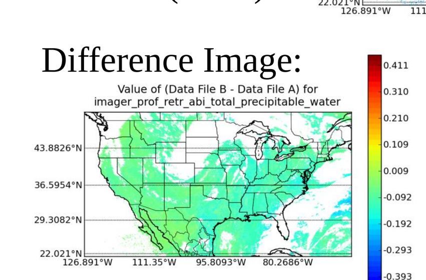


Spec-level (1x) noise, calibration offset, navigation error, and striping affects TPW, but the algorithm appears robust.

Total Precipitable Water (TPW)



Difference Image:

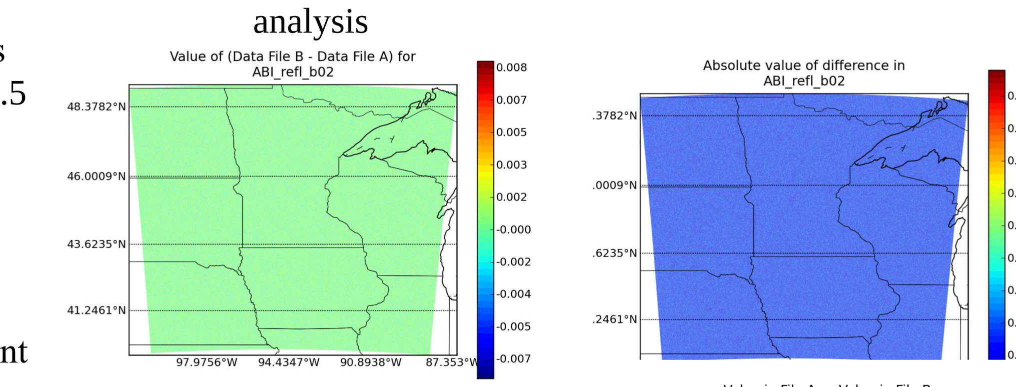


Epsilon used here is 0.0

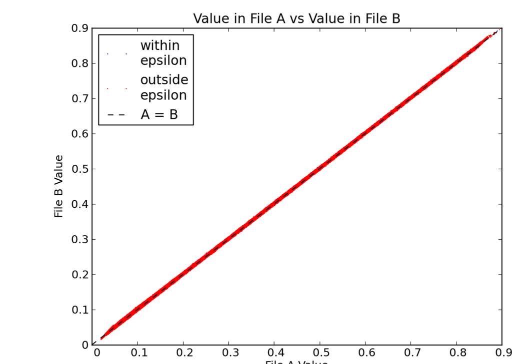
"What if" noise simulations for ABI 0.6 um visible band (band 2)

- Efforts part of GOES-R 'triage' board on waivers
- CIMSS proxy ABI data via the AWG project at 0.5 km without any noise
- Add random (gaussian) noise (mean of zero and standard deviation of 1/SNR):
  - 1000:1 at 100% (equates to 50:1 at 5%)
  - "current spec on dark end"
  - 300:1 at 100% (equates to 15:1 at 5%) "current spec on bright end"
- Bin data to 2^12 bins
- Start with a dark/'worst case' scene (12 UTC)
- Also look at bright scene (17:30 UTC)
- Displayed in McIDAS-V

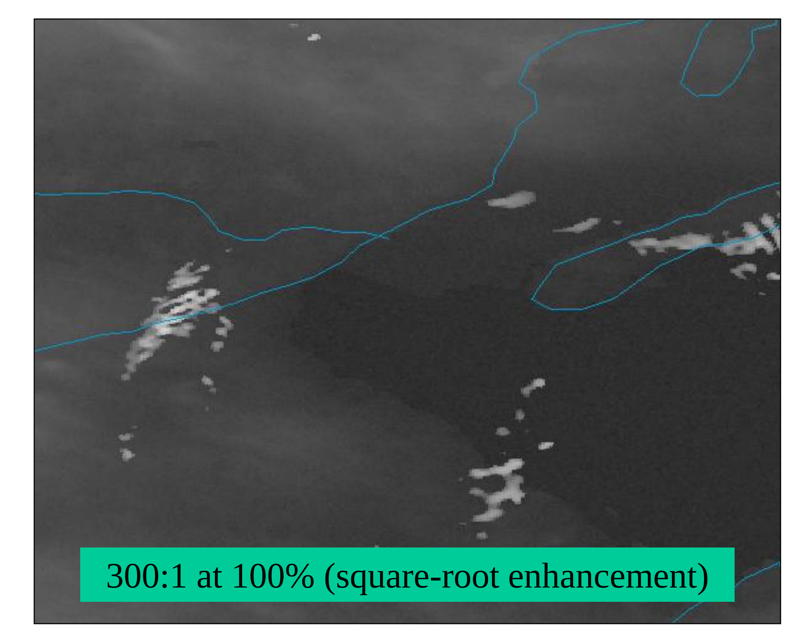
Glance output for 300:1 vs 200:1 "bright" scene analysis



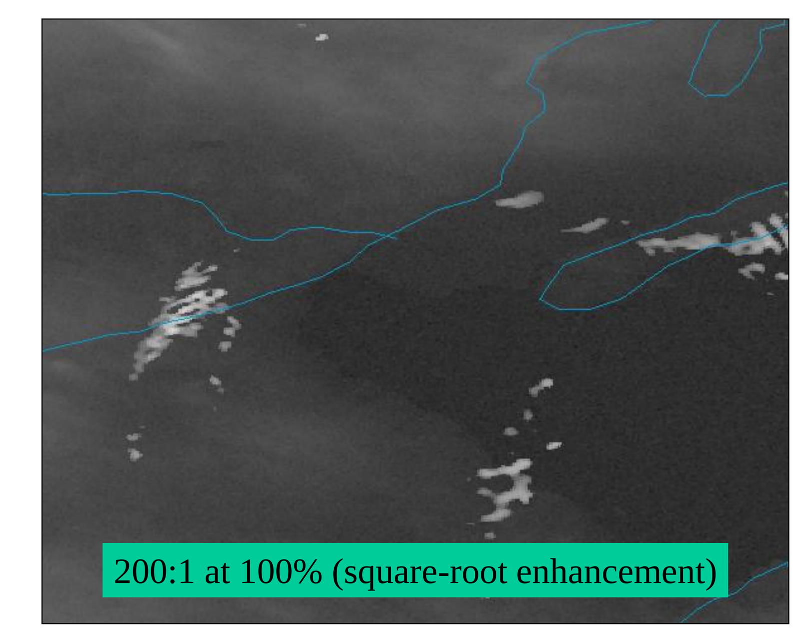
General Statistics
- a_missing_value*: None
- b_missing_value*: None
- epsilon*: 0
- max_a*: 0.8989
- max_b*: 0.8989
- min_a*: 0.021 z
- min_b*: 0.01465
- num_data_points*: 4000000
- spatially_invalid_pts_ignored_in_a*: 0
- spatially_invalid_pts_ignored_in_b*: 0
- trouble_points_count*: 3766370
- trouble_points_fraction*: 0.9416



Noise is more apparent in a darker scene as the signal to noise ratio (SNR) decreases…

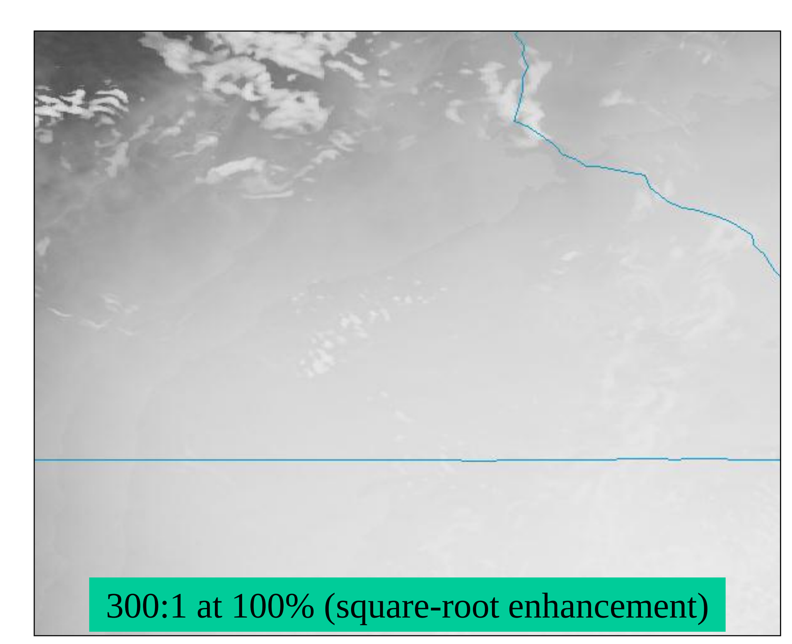


300:1 at 100% (square-root enhancement)

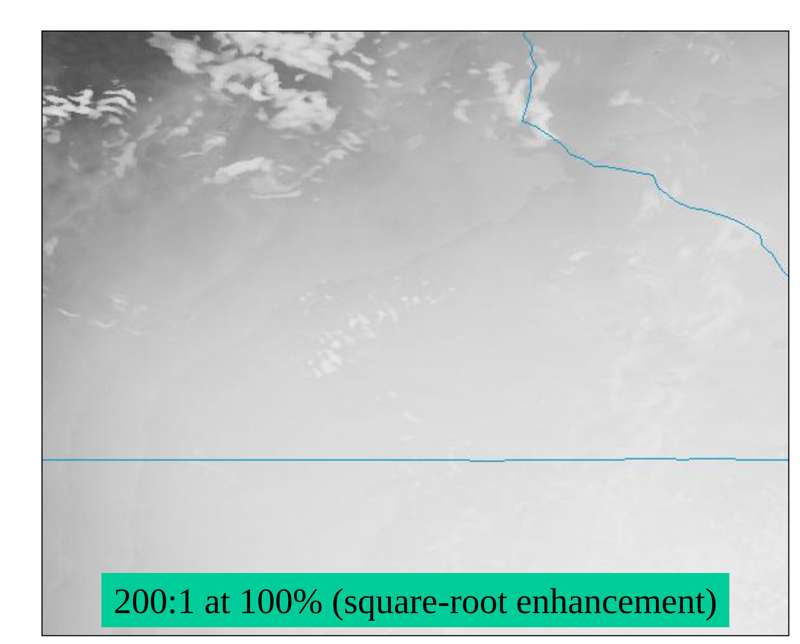


200:1 at 100% (square-root enhancement)

Noise is not visibly apparent in a bright scene…



300:1 at 100% (square-root enhancement)



200:1 at 100% (square-root enhancement)

GRAFIIR SUMMARY

GRAFIIR is to

1. **Implement a facility environment (including leveraging GEOCAT and the AIT "Framework") to allow easy application team proxy data and product algorithms.**
2. **Design an efficient approach in coordination with ABI sensor and algorithm scientists to analyze the effects of sensor components such as noise, navigation, band to band co-registration, optical diffraction, stripping and other effects identified to be significant on product algorithms and imagery.**
3. **Assist the government's response to ABI instrument waivers requested by industry by providing statistical analysis, reports, and imagery.**
4. **The CIMSS GRAFIIR Team has responded to 3 ABI waiver/deviation requests to date; 2 others are currently in progress.**

GRAFIIR is now ready to conduct systematic and detail analysis of ABI instrument impacts on key products.